In Proceedings, 43rd Annual Meeting Southern Weed Science Society: 1990 January 15-17; Atlanta, GA. 45

SPRAY DISTRIBUTION OF BOOMLESS NOZZLES: THE BOOMJET 5880, RADIARC AND BOOM BUSTER. J. H. Miller, Southern Forest Experiment Station, USDA Forest Service, Auburn University, AL 36849.

ABSTRACT

The patterns of spray distribution are described for three boomless nozzles that are commonly used, or have promise, for forestry applications: the BoomJet 5880 cluster nozzle (Spraying Systems Co.), the Radiarc (Waldrum Specialties), and the Boom Buster (Evergreen Products). Spray distribution patterns were determined using regularly spaced collection cups and multiple tractor passes at 2-3 mph. Modified configurations of the Radiarc produced the most even distribution pattern, while 5- to 14-fold differences in rate occurred within the pattern of the BoomJet. The Boom Buster Model 140 yielded within swath peaks that were 28-47% greater than the average. Nozzle alignment is critical when using boomless nozzles and should be checked frequently during operational treatments.

INTRODUCTION

Boomless nozzle systems are increasingly used for tractor applications of forestry herbicides in the South with little published information on their spray distribution patterns. Commonly-used nozzles are the BoomJet 5880 and the Radiarc, which have been borrowed from right-of-way applications. The Boom Buster is a recent addition to boomless technology, introduced in 1988, with claims of an even distribution pattern. Boomless nozzles are needed in forestry applications for both brush and herbaceous weed control treatments using both foliar- and soil-active products. Even distribution patterns are critical for applications over the top of crop seedlings to minimize herbicide caused damage and mortality.

The usual setup of the BoomJet 5880 nozzle system has five spray tips mounted on a circular head: a center 95°-110° flat fan tip that sprays below the nozzle, two off-center (OC) tips that spray to the left and right, and two 5" narrow fan tips that spray to the extreme left and right. This boomless cluster nozzle sprays down and out perpendicular to the tractor's direction of travel.

The creative contributions and extra effort of Erwin Chambliss in the development and enactment of this study are gratefully acknowledged.

Nozzles for these tests were supplied by Spraying Systems Co., North Avenue, Wheaton, IL 60188; Waldrum Specialties, Inc., SkyRun II-Suite A, 4050 Skyron Dr., Doyleston, PA 18901; and Evergreen Products, Inc., P.O. Box 598, Millen, GA 30442.

Use of trade names is for the reader's information and does not constitute official endorsement or approval by the U.S. Department of Agriculture to the exclusion of any other suitable product or process. Pesticides used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all precautions on the label. Store pesticides in original containers under lock and key out of the reach of children and animals, and away from food and feed. Remember **to read the entire product** label and use only according to label instructions.

The Radiarc is a control droplet application system. It uses direct electric power with rheostat adjustments to oscillate, in opposite directions, two circular heads that contain 11 tips each. It combines spray pressure (about 40 psi) and centrifugal force to produce uniform droplets of large diameter to minimize drift. The 22 tips are evenly spaced around half the circular heads--producing semi-circles of radiating spray that merge through oscillation behind and to the sides of the tractor. Spray pattern versatility is provided by the following range of spray tip sizes (diameter of orifice) that are available from the manufacturer: 0.030 in., 0.045 in., 0.070 in., 0.085 in., and 0.101 in. These tip sizes as well as plugs can be placed in any of the 22 positions to regulate output. The manufacturer states that less control over precise droplet size occurs when using the 0.070 in. and larger tips.

The Boom Buster nozzle is an elongated off-center nozzle made of stainless steel with a gaping orifice opening from the end and running along the lower side. A nylon diffuser blade is positioned within the end part of the orifice where the "hard edge" is formed that ejects the spray solution the furthest. By mounting one or two nozzles perpendicular to the direction of tractor travel, the broad spray fans are ejected to the side and behind the spray vehicle.

After using the BoomJet 5880 nozzle for treating kudzu (*Pueraria lobata*) and herbaceous competition, poor control has been repeatedly observed in strips within the spray swath. Only one brief account of the spray distribution of the BoomJet 5880 is available in published reports (5) and nothing on the Radiarc or Boom Buster. The present study was therefore undertaken to determine the spray distribution of these boomless nozzles,-with selected modifications, so that future treatments may be more effectively planned and applied.

METHODS

For all systems, new or only slightly-used nozzles were tested and only water was used. Nozzles were mounted at different test heights on a spray system attached to a John Deere 450B crawler tractor that has been previously described (3). All nozzles were aligned using a bubble level. Spray pressure was maintained at 20 psi for the BoomJet and 40 psi for the Radiarc and Boom Buster, which yielded good extensions of the swath widths with minimal fine droplets. Spray output in gal./min (gpm) was determined for each nozzle configuration by draping plastic over the nozzle and catching the.output in a pail for one minute. Three measurements were averaged.

Tests were performed in an area partially protected from wind behind the U.S. Forest Service Laboratory at Auburn University. Full protection from surface winds was provided on two sides by buildings and a wall.' Detached buildings provided partial protection on the remaining two sides, as did scattered corridors of mature trees. Wind was monitored during trials and tests were suspended when gusts exceeded 6 mph. Tests were performed on a paved surface within the sheltered area.

Distribution across trial spray swaths was measured with weighted plastic cups (4 in. diam., 16 oz) regularly positioned at 1-3 ft intervals near the tractor and at 2 ft intervals thereafter, out to 32 ft on either side. Distribution measurements were made while the tractor passed repeatedly in one direction over the cups at 2-3 mph. Fifteen passes were used for each measurement, so as to determine the distribution in a dynamic operating mode. Cups with spray solution were immediately collected, the outside wiped clean, and weighted inside an adjoining building on a balance accurate to 0.01 g.

BoomJet

The BoomJet nozzle can be equipped with four standard sets of interchangeable spray tips in accordance with Spraying Systems Company's catalog (4). As specified in the catalog, these four sets of tips provide outputs and theoretical swath widths at 20 psi as follows: a) 1.8 gpm and 33.5 ft, b) 2.8 gpm and 39.5 ft, c) 6.1 gpm and 47 ft, and d) 12 gpm and 56 ft. To gain a wide spray swath and high flow volumes, forestry applications usually use the last two sets. For these tests with the BoomJet, the "c" set was used, which consists of the following tips: a 9506, two OC 20's, and two 0520's. Several modified configurations were also ran.

Radiarc

for the Radiarc, the spray pattern of two setups were characterized, the "uniform pattern" (so named in the manufacturer's instructions) and a modified setup that was an attempt to make the pattern more even. The spray tip sizes in the two configurations were as follows:

Tip Position:	1	2	3	4	5	6	7	8	9	10	11
						(inch)					
						Uniform Pattern					
top	0.045	plug	0.045	0,045	0.045	0.045	0.045	0.045	0.045	0.045	plug
bottom	plug	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	plug	0.045
						Modified					
top	0.045	plug	0.045	0.070	0.070	0.070	0.070	0.070	0.045	0.045	plug
bottom	plug	0.045	0.045	0.070	0.070	0.070	0.070	0.070	0.045	plug	0.045

Plugs are used to decrease the output on the outer edges, which naturally produce areas of higher rates inherent with the semi-circular spray pattern. One Radiarc was mounted behind the tractor at a 6 ft height, horizontal to the ground and tilted up 10° to the direction of travel (as specified in operating instructions).

Boom Buster

Of the six available models of the Boom Buster, the smallest--model 140--was tested. Two model 140's were connected with a pipe-tee for dual applications to both sides of the tractor. Nozzles were 3.5 in. apart. The supply line was two times the size of the pipe tread, as specified in the instruction. Mounting height was 4 ft.

For each nozzle setup, the estimated swath width was determined by measurements made on the graphical plots of the patterns. The swath edge was judged as one-half the length of the outside swath taper. Collection points within the estimated swath width were used to calculate a coefficient of variation (CV) for each nozzle configuration.

RESULTS

BoomJet 5880

The spray distribution from the BoomJet cluster nozzle moving at 2-3 mph is characterized by three peaks (Fig. 1 and 2). Distribution peaks occur immediately behind the tractor from the 95° flat-fan tip and at 20-24 ft left and right of center where the OC and 5° tips overlap.' A 5- to 14-fold difference was found between low points and peaks, resulting in CV's of 61-65%. With forward movement, output from the 5° tips are bent back onto the "hard edges" of the OC tips and this combined spray forms the outer peaks. The low points in the distribution pattern vary from 3-12 ft from center. The low-output areas are caused by the incomplete overlap of the 95° and OC tips as well as by the low output from the inner portions of the OC tips.

As mounting height was increased, the BoomJet pattern changed, but with little apparent consistency except that the central peak was narrowed at the base. A modified setup recommended by Wehr et al- (5) gave a marginal improvement in evenness when mounted at the 6 ft height (Fig. 2) over the standard setup (Fig. 1) as indicated by a CV of 42%. At the 3 ft mounting height, the CV was 61% with the modified setup showing no improvement in evenness.

Replacement of the 95° tip by a TK 7. 5 FloodJet (4) produced a broader fan immediately behind the tractor (Fig 3a) and a slightly improved CV of 45%. The long body of the TK tip was mounted parallel to the ground using a swivel. With this modification the central peak was replaced by two smaller peaks at 5 and 7 ft from center, but the two low output areas remained. Another modification tested the replacement of the 95° tip with two 150° flat-fan tips (15003) mounted on a double swivel, each having outputs of 0.3 gpm (Fig 3b). An erratic but more even pattern resulted with a CV of 40%. The uneven center portion of the pattern was probably caused by spray interference from the overlapping 150° flat fans.

Radiarc

The Radiarc (Fig. 4) has an estimated swath width of about 38 ft. The "uniform pattern" is characterized by two outside peaks gradually tapering to an inner flat valley of low output (Fig, 4a). Edges are very distinct. The peak areas have about twice the rate of the center valley and 40-44% greater output than the mean. The CV for the "uniform pattern" was 36%. By substituting larger tips in the center of the circular heads, the modified configuration approached an even distribution (Fig. 4b), with the lowest CV of 18%. Maximum deviations were only 22% of the mean. However, the spray output of 9 gpm may be excessive for some forestry applications (Table 1) and thus, all tips should be decreased one size for future tests.

Boom Buster

The dual mounted Boom Buster nozzles produced slightly unequal patterns (right and left halves), which is an indication of between-nozzle variation (Fig 5). The CV's for the two nozzles were 18% and 33%--further indications of their non-uniformity. Both showed small peaks in the center of their areas of coverage. Peaks were 28% and 47% greater than the mean output within the estimated swath width and the overall CV was 26%. The swath width was judged to be about 29 ft for the dual setup.

for all test nozzles, a summary is given in Table 1 of the outputs (gpm), estimated swath widths, and estimated gallons per acre. With the BoomJet, replacing the OC 6's with OC 20's increased the output by 31%. With the Radiarc, the modified setup using the larger 0.070 in. tips that yielded the most uniform pattern, increased the output by 73%.

DISCUSSION

By close inspection of the BoomJet plotted patterns it is apparent that the most even distribution, although still variable, can be obtained when spray swaths are spaced every 30 ft, edge-to-edge or center-to-center. The 30-ft spacing matches the peak outputs of one pass with the low-output areas of the preceding pass. When maximum coverage and minimum overlap is required then edge-to-edge swath applications should not overlap more than 5 ft to prevent double spraying by outside peaks.

The varying weed control in strips when treating areas with the BoomJet 5880 nozzle is apparently due to the uneven pattern documented in these tests. The streaks are more evident after treating herbaceous weeds and kudzu, than with those of hardwood control, unless hardwood control is for pine release. If for' pine release, then higher rate streaks can cause damage and mortality when using herbicides with marginal seedling tolerance.

Continuous cover of herbaceous weeds and kudzu not only gives evidence of lower-rate streaks left by the BoomJet nozzle but also of variation in the effective swath width. Repeated field measurements have shown the effective swath width to be about 50 ft, depending on the ground speed of the tractor during application. As ground speed increases, the outer 5^{0} tips and OC patterns are increasingly curved back, decreasing the effective swath width. The SO-ft average coincides with the distance between the outer peaks of the pattern shown in Figures 1 and 2. The droplet size from the 5^{o} tip averages about 10,000 microns (5)--exceedingly large and ineffective for foliar-active herbicides--which also tends to shorten the effective swath width. It has also been observed that applications made with wind gusts up to 10 mph greatly increase the outer peaks and makes the swath width highly variable.'

Less severe within-swath rate variation occurred with the unmodified Radiarc and Boom Buster nozzles. With the modified Radiarc, the most even distribution was achieved for these tests, which would make this the nozzle of choose for critical applications over young seedlings. There is still some question whether the Boom Buster would be suitable for herbaceous weed control treatments using herbicides with margin seedling tolerance. The narrow swath widths of both of these nozzle systems also detract from their cost-effectiveness for forestry applications.

From field observations, the lack of an even spray pattern appears to be less critical when spraying sprouting hardwoods, especially with soil-active herbicides. Since the herbicide is taken up by far-reaching root systems, only very small target stems are missed. Past research has shown that even narrow streaks of herbicide at regular spacings can effectively control sprouting hardwoods (1,2). Uneven control is also less common when treating brush with effective foliar-active herbicides. The uneven spray pattern is less critical because the foliage of small hardwoods and shrubs is often uneven in distribution; the outside spray peaks are frequently intercepted by the sides and tops of hardwoods and shrubs; also, the peak behind the tractor treats the brush that has been pushed down by the passing tractor, which can have considerable foliage to cover with spray. A bigger factor in uneven distribution in ground spraying by boomless nozzles results from the interception of spray by taller plants next to the sprayer--a case of shielding. Thus, the versatility in mounting height is an important advantage with boomless nozzle systems.

All boomless nozzle systems are very sensitive to horizontal alignment, whereby minor changes cause large shifts in patterns. A bubble level was used to set and check alignment in these tests, when it became evident that ocular alignment was inadequate. It is apparent that minor terrain features can translate into.major variation for within-swath rate when using these boomless nozzles.

RECOMMENDATIONS

Variable coverage and control can be expected from the BoomJet 5880 nozzle, which makes it questionable for herbaceous weed control and release applications over crop seedlings, unless herbicides with wide seedling tolerance are used. A modified Radiarc or trial treatments with the Boom Buster may be more suited for such critical applications.

For site preparation, woody plant treatments may be applied by the all three nozzles when using effective herbicides at the higher recommended rates. Low-rate streaks are expected to be Tess of a problem for effective soil-active products.

The SO-ft effective swath width by the BoomJet yields high productivity in forestry applications, which is a critical factor in judging the utility of any nozzle. But for more uniform applications, the recommended 30-ft swath spacing is less efficient than the 38 ft swath by the Radiarc 'and similar to the 28 ft swath of the Boom Buster. All boomless nozzles must be carefully and consistently maintained for effective applications. Nozzle alignment is critical when using boomless nozzles and should be checked frequently during operational treatments.

LITERATURE CITE5

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Table 1. Spray output, test mounting height, estimated swath width, and estimated GPA three boomless nozzles and their modifications.

Nozzle setup	output	Mounting height	Est. swath width	GPA[1]
	(gpm)	(feet)	(feet)	--
	BoomJet 120 psi)			
Standard setup:				
OC 20, 0520, 9506	6.6	3		
		6		
		13		
Modified setups:				
OC 6, 0520, 9506	5.1	3		
		6		
OC 20, 0520, TK 7.5	6.5	6		
OC 20, 0520, 2 ea 15003	6.1	6		
	Radiarc (35 psi)			
Uniform pattern	5.2	6	38	34
Modified setup	9.0	6	38	58
	Boom Buster (35 psi)			
Model 140, 2 each	6.1	4	29	52

[1]GPA is estimated by assuming a travel speed of 2 mph.

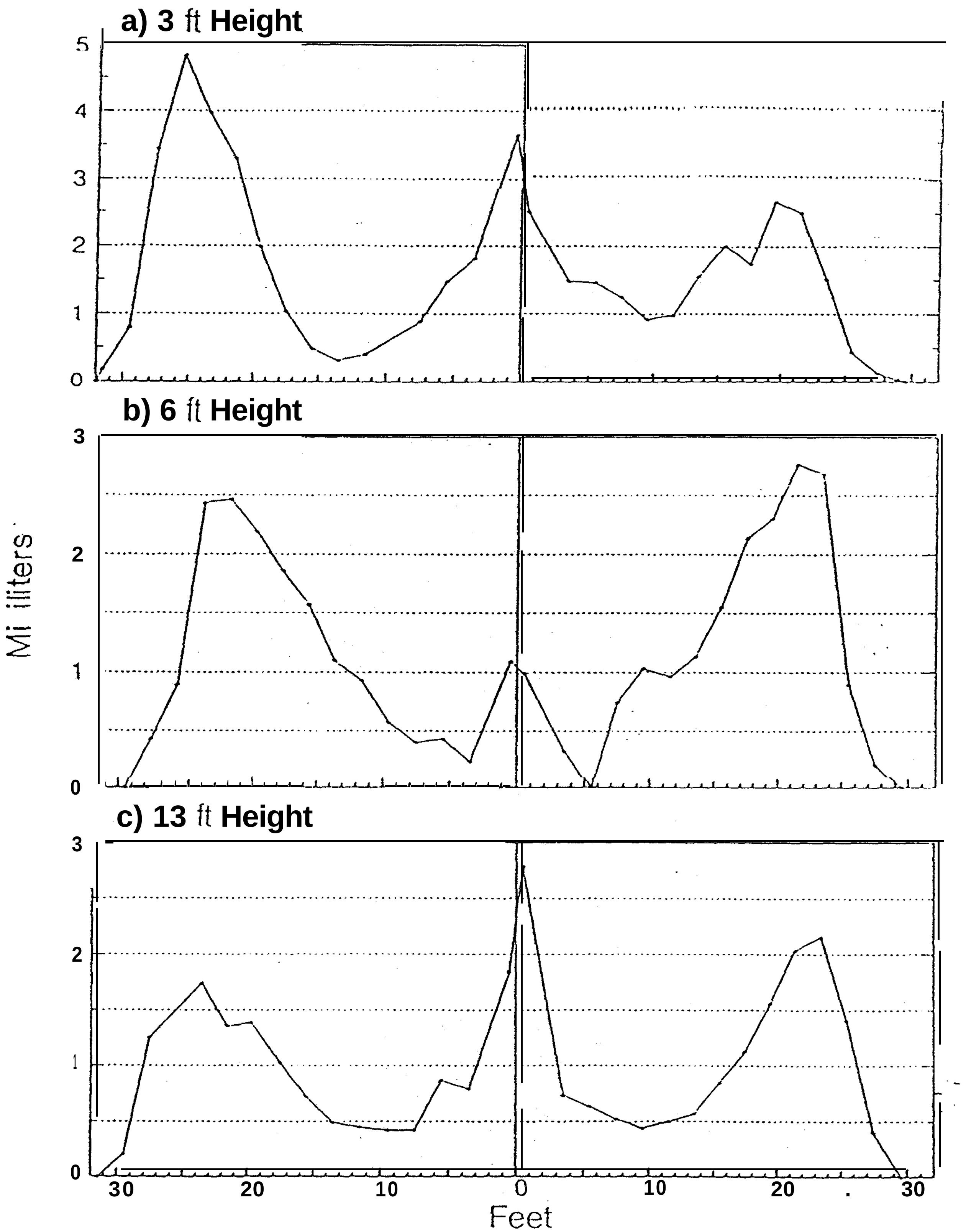

Figure 1. Spray distribution patterns after 15 passes of the BoomJet 5800 nozzle mounted on a moving tractor at heights of a) 3 ft, b) 6 ft, c) 13 ft. The spray tips on the BoomJet nozzle were OC20, 0520, and 9506.

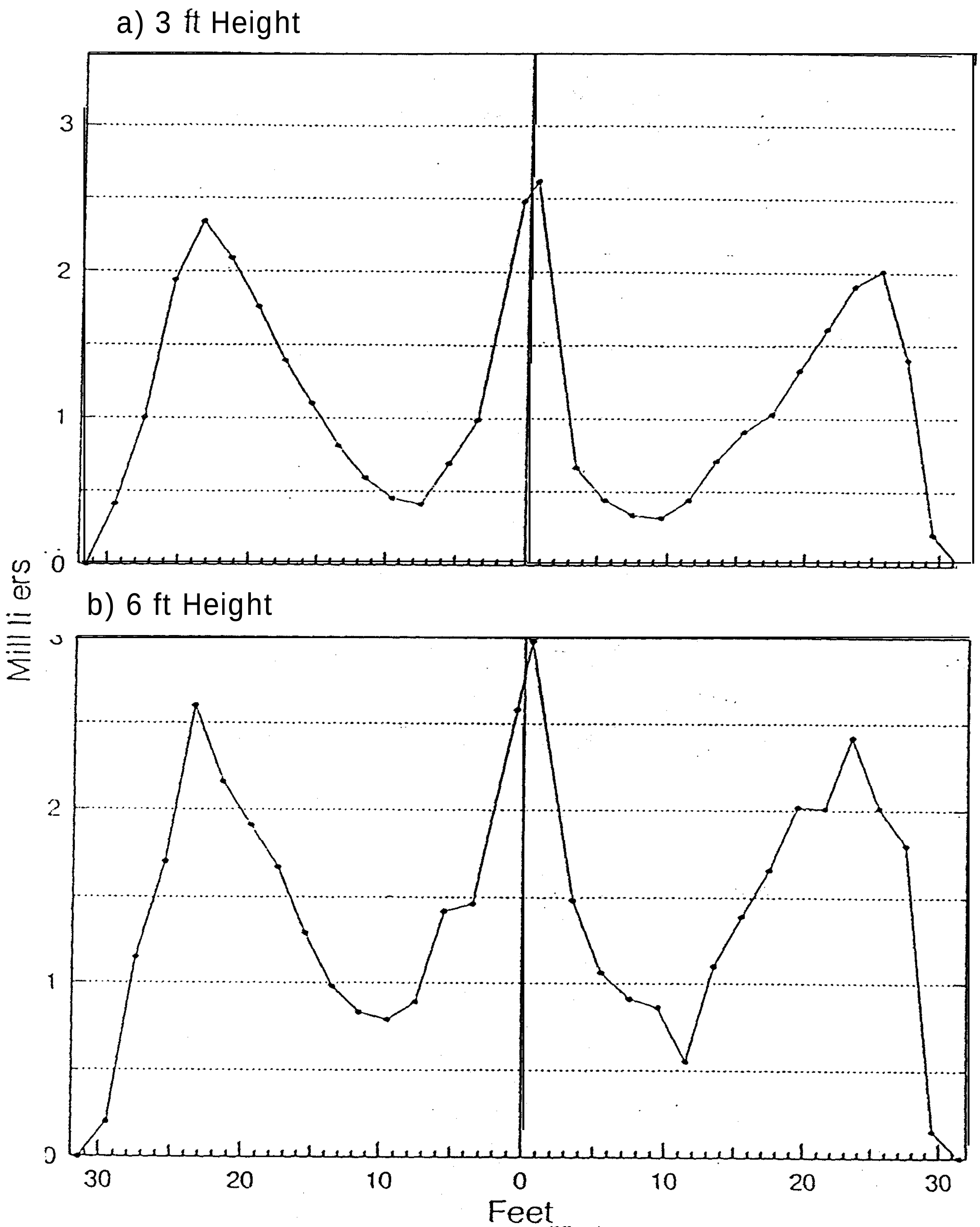

Figure 2. Spray distribution patterns of a modified configuration of the BoomJet 5800 as recommended by Wehr et al. (5) and tested on a moving tractor at two mounting heights: a) 3 ft and b) 6 ft. The spray tips on the BoomJet nozzle body are OC6, 0520, and 9506.

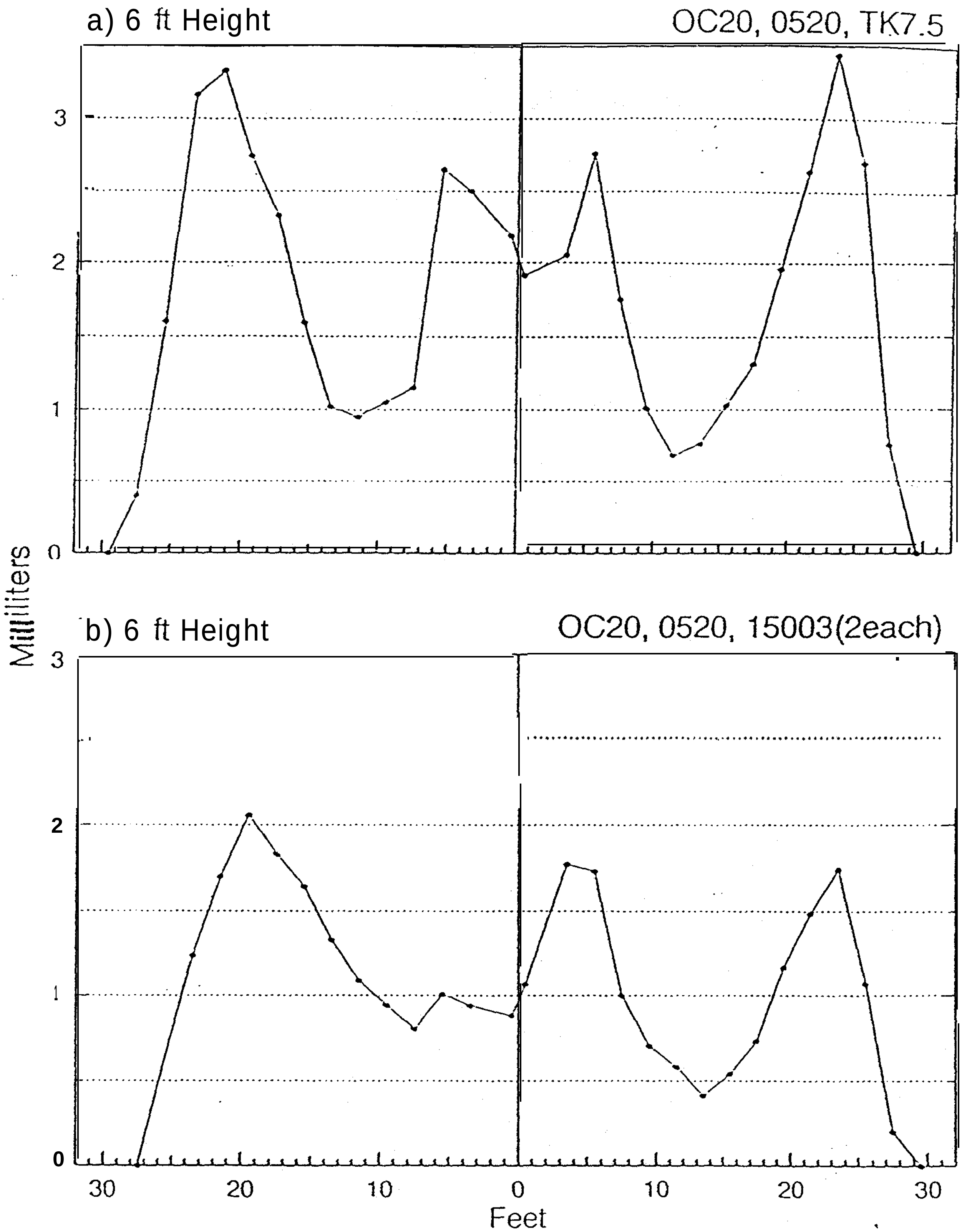

Figure 3. Spray distribution patterns of new configurations of the BoomJet 5880 nozzle mounted on a moving tractor at 6 ft in height.

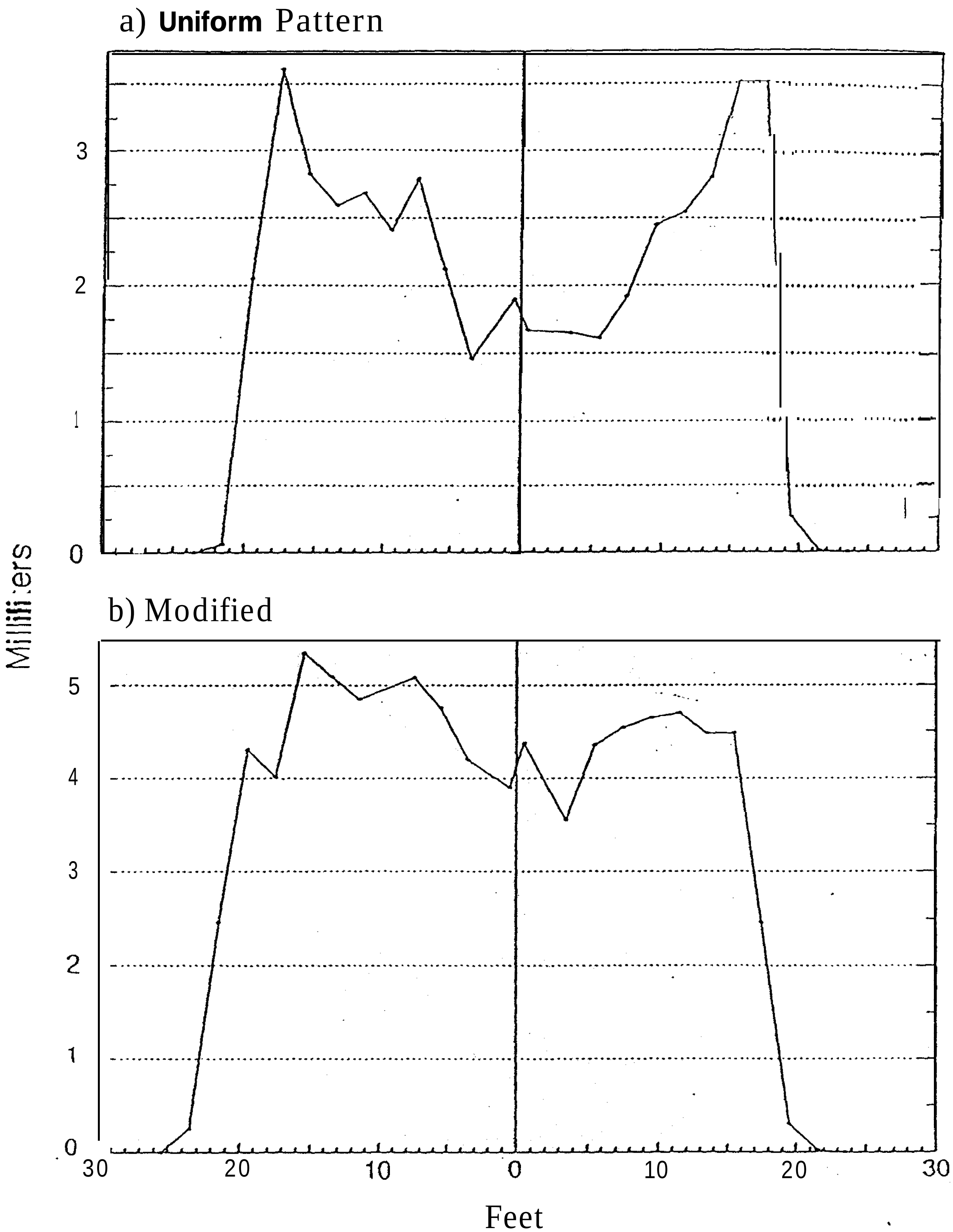

Figure 4. Spray distribution patterns of the radiarc nozzle with the:
a) uniform pattern of tips and b) a modified setup.

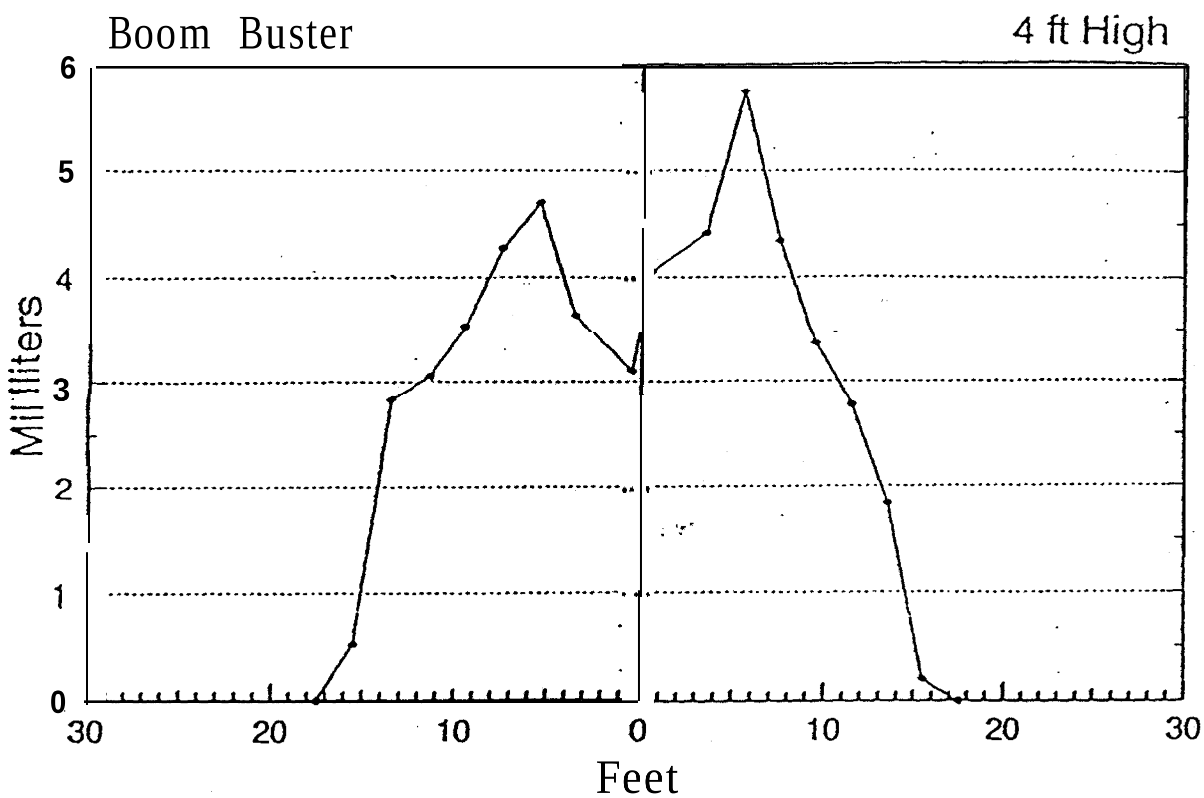

Figure 5. Spray distribution pattem of dual mounted Boom Buster nozzles, . . Model 140.